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LCEC Guidelines

on Preparing Technical Proposal for Water Conservation Practices in Agriculture

Applies to LEA financing mechanism loans

Prepared by the Lebanese Center for Energy Conservation

Introduction:

The Lebanese Environmental Action (LEA) is a national financing mechanism dedicated to the financing of environmental loans for water, air and environment. LEA is a joint initiative between the Central Bank of Lebanon (BDL) and the Ministry of Energy and Water (MEW).

As part of the contract signed between BDL and the Lebanese Center for Energy Conservation (LCEC) under the name "Technical Support Consultancy Services Agreement in Energy Efficiency and Renewable Energy", the Technical Support Unit to the Central Bank of Lebanon (BDL) at LCEC is dedicated to offer BDL technical assistance to evaluate the eligibility of submitted loans under LEA.

Important Notes:

1. *This project proposal guideline is designed to help potential beneficiaries, consultants, and contractors in preparing comprehensive technical reports and proposals about water conservation practices in the agriculture sector.*

2. *This project proposal template is a mandatory requirement towards facilitating the green loan application process through the national financing mechanism LEA.*

3. *This project proposal template is prepared by the Lebanese Center for Energy Conservation-Technical Support Unit to the Central Bank of Lebanon, and is available for public use.*

4. *This guideline will be updated constantly, kindly always refer to the latest version.*

5. *For questions, clarifications, or suggestions, please contact the LCEC: 01-569101 or by email: energy@lcec.org.lb*

Evaluation of projects requesting financing of water conservation practices in the agriculture sector under LEA will be based on these issued Guidelines. Contractors are entailed to abide by the requirements set in these guidelines and must submit the technical reports following the steps and regulations clearly identified.

I. Introduction

Agriculture consumes, on average, 70% of the water budget of Lebanon. It also reduces water availability by polluting surface and groundwater with runoff fertilizers and pesticides. Reducing the use of water in agriculture, without compromising yield, is possible. More crop per drop is a global campaign aiming at improving water use efficiency in agriculture. It focuses on ways and means to produce more yield with less water consumption.

High efficiency irrigation systems such as drip, soilless agriculture also known as hydroponics, using non-conventional water (harvested water, treated wastewater and greywater), and new crop varieties help achieve more crop per drop. Such measures, if combined, can reduce the overall water footprint of agriculture by up to 50%.

Surface/furrow irrigation is only 40% efficient compared to 75% for sprinklers and 90% for drip, of course if the irrigation system is designed, installed and used properly. Higher water savings can be achieved if harvested or recycled water is used. Taking the example of 10,000 m^2 of land, the water needed at peak is around 6 mm/day or a volume of 60 m^3 per day. Using surface irrigation and factoring in efficiency, this land will need 150 m^3/day compared to only 67 m^3/d for drip irrigation. The saved volume of water is 83 m^3, almost 55% compared to surface irrigation.

A much more accurate way to estimate water savings is Water Use Efficiency (WUE). Recent trials in Lebanon have shown that drip and micro-sprinkler irrigation do not only reduce water but also increase yield. WUE is a ratio of tons of crop produced and per m^3 of water used. If water consumption is reduced by using efficient irrigation and yield is increased accordingly WUE increases

II. Efficient Irrigation for Agriculture

1. Applicability for LEA

It is important to pinpoint that not all items under water conservation practices in the agriculture sector are financed under the LEA financing mechanism. This section provides a clear list of the financeable items to prepare the technical study for the efficient irrigation system in agricultural practices.

Efficient Irrigation system items for agricultural practices eligible under the LEA financing mechanism are:

1. Emitters;
2. Pipes;
3. Valves and relevant accessories;
4. Backflow preventer;
5. Pressure regulator;
6. Controller;
7. Flow meters;
8. Fertilizer mixer;
9. Filters;
10. Moisture and other sensors;
11. Irrigation installation cost;
12. Others, as seen applicable.

It is important to note that only the cost of the efficient irrigation system will be financed under the LEA financing mechanism. The cost of the agricultural crops for commercial purposes is not financed.

Note that the cost of the pumps will not be covered.

2. Requirements under LEA

This section covers the requirements under LEA and the information to include in the technical study. All requirements are further detailed in section 4, Efficient Irrigation System Design. As a minimum, the study should include the following:

a. Description of the current state of the agricultural land. Specify:
   - Planted area (in m^2);
   - Water source (municipal, rainwater, treated effluent wastewater, private source), quantity and quality;
   - Current means of irrigation;
   - Climatic characteristics of the area;

b. List of crops to be planted;
c. Planting patterns/programs and drawings;
d. Efficient Irrigation System Design and specifications;
e. Irrigation Scheduling per Hydrozone;
f. Efficient irrigation network design layout and drawings ;
g. Type of fertilizers, if any, and frequency of application;

h. Type of soil amendments, if any, with justification of the need. Specify the quantity used in m^3/m^2;
i. Environmental Sustainability Analysis;
j. Datasheet of components seeking financing under LEA;
k. Official BOQ from the supplier/contractor that should include:
   - Supplier/Contractor details;
   - Components' unit cost in USD/unit or LBP/unit;
   - Installation cost (in USD or LBP).

3. Water Reduction Target

Agricultural water efficient irrigation measures submitted under LEA should have at least **<u>45%</u>** reduction of the project's water requirement in comparison to surface irrigation.
<u>Projects with less than 45% water reduction will be disqualified</u>.

4. Efficient Irrigation System Design

This section provides guidance on how to prepare and present the efficient irrigation system for agricultural practices technical study.

4.1 Hydrozones and Specifications

A hydrozone is an area containing crops with similar water requirements that will be irrigated on the same schedule, using the same irrigation method. The grouping of plants into areas of similar water requirements allows the irrigation system to be designed and managed so that the optimal depth of water can be applied. In areas of crops with different water requirements, it is necessary to divide the irrigation system controller. If this is not achieved, then the irrigation system will be operated to provide enough water to one crop and the other crop will be overwatered.

Complete and insert Table 1 in the project proposal. Add rows as needed.

Table 1 List of Hydrozones

<table>
<tr><th>Hydrozone</th><th>Name of Crops</th><th>Irrigation Type (drip, sprinkler, bubbler, etc.)</th><th>Surface Area of Each Hydrozone (in m²)</th></tr>
<tr><td rowspan="3">1</td><td>Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="3">Insert text here</td></tr>
<tr><td>Insert text here</td></tr>
<tr><td>Insert text here</td></tr>
<tr><td rowspan="3">2</td><td>Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="3">Insert text here</td></tr>
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<tr><td>Insert text here</td></tr>
<tr><td rowspan="3">3</td><td>Insert text here</td><td rowspan="3">Insert text here</td><td rowspan="3">Insert text here</td></tr>
<tr><td>Insert text here</td></tr>
<tr><td>Insert text here</td></tr>
</table>

4.2 Irrigation System Components and Specifications

In general, the irrigation system consists of, but is not limited to, the following components:

1. Application System:
   a. Emitters.
2. Distribution System:
   a. Lateral pipes.
3. Conveyance System:
   a. Main lines;
   b. Sub main lines;
   c. Valves;
   d. Pressure regulator.
4. Commanding System:
   a. Pumps;
   b. Filters;
   c. Fertilizer mixers;
   d. Controller;
   e. Flow meters;
   f. Moisture and other sensors.

4.2.1 Emitters

The most suitable efficient emitter should be selected for irrigation. Irrigation emitters deliver water to plants covering either the whole planted surface (plants and soil) such as sprinklers, micro-sprinkles or directly to each plant such as drippers. The efficiency in water delivery of emitters ranges from 75% for sprinklers to 90% for drippers in comparison to traditional measures such as hose irrigation that has an efficiency of 50% as compared to surface irrigation that have an efficiency of 40%. Drippers, sprinklers, etc. should be sized to provide even and adequate water distribution to plants. The pressure and water flow requirements of irrigation components are specified by the manufacturer and should be respected in the design. Improper design leads to wasted water. The number of emitters per plant is determined using the water requirements of the plant and the flow characteristic specific to the emitters.

Complete and insert Table 2 in the project proposal. Add rows as needed.

Table 2 Emitters' Specifications

Hydrozone	**Irrigation Type (drip, sprinkler, etc.)**	**Emitter Brand and Reference Number**	**Emitter Flow Rate (in liter/hour)**	**Quantity**	**Hydrozone Flow Rate (in liter/hour)**
1	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*

Please provide emitters datasheet, highlighting selected model and operating conditions, if applicable.

a. Sprinkler Irrigation (Sprinklers and Micro-sprinklers)

Sprinkler irrigation is a method of applying irrigation water, which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops, which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable an efficient and uniform application of water. Proper overlap of water streams jetting from the sprinklers should ensure even coverage of the entire irrigated surface.

b. Drip and Micro-Irrigation (Drippers)

One of the most effective forms of irrigation is micro or drip irrigation. Drip irrigation employs emitters that slowly apply water to crop root zones. Drip irrigation usually consists of a pressurized tubing system that runs along crop/plant rows. These tubes are fitted with drippers (inline or online) at specific distances. The two distinct features of micro-irrigation are high irrigation frequency and localized water application to only the root zone.

The application efficiency of irrigation systems is the amount of water delivered to the plant versus the total amount of water sent out into the system. The efficiency of each irrigation method is shown in Table 3. It also shows the amount of water needed for each irrigation method compared to the amount of water needed by the crops. Note that these efficiencies are just indicative.

Table 3 Irrigation Methods' Efficiency

Irrigation method	Application efficiency	Amount of water required to meet crops water demand	% water savings compared to surface irrigation
Surface Irrigation	40%	2.5 x amount water needed by crops	---
Hose Irrigation	50%	2 x amount water needed by crops	20%
Sprinkler	75%	1.33 x amount water needed by crops	46%
Drip	90%	1.11 x amount water needed by crops	55%

4.2.2 Pipes

Pipe sizing depends on the required pressure on the dripper or sprinkler etc. and the pressure loss in the pipes, laterals, mains and components (filters, mixers, gages, valves). Water velocity in the pipes should be kept between 1.5 to a maximum of 2 m/s. Excessive water velocities leads to the rapid wear and tear of the network. Software or tables in the pipe datasheet can be used to determine pipe diameters. The tables will indicate pipe diameter vs. flow at a given flow velocity (1.5 to 2 m/s). Before sizing the lateral pipes, the type of pipes should be specified (PVC, HDPE, PEX, etc.). The sizing of the lateral pipes is done in reverse. The first pipe to be sized is the pipe reach supplying toe last of the further emitter from the valve. When the size has been established for that reach, the next reach in, supplying the last two emitters should be sized. The process continues, moving upstream from the last emitter and toward the valve.

Complete and insert Table 4 in the project proposal. Add rows as needed.

Table 4 Piping Details

Hydrozone	Lateral Pipe Diameter (in mm)	Quantity	Unit Length of Pipe (in lm)	Submain Line (in mm)	Quantity	Unit Length of Pipe (in lm)	Main Line (in mm)	Quantity	Unit Length of Pipe (in lm)
1	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
	Insert text here	*Insert text here*	*Insert text here*						
	Insert text here	*Insert text here*	*Insert text here*						
2	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*			
	Insert text here	*Insert text here*	*Insert text here*						
	Insert text here	*Insert text here*	*Insert text here*						
3	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*			
	Insert text here	*Insert text here*	*Insert text here*						
	Insert text here	*Insert text here*	*Insert text here*						

Please provide datasheet, highlighting selected model and operating conditions, if applicable.

4.2.3 Valves

Upon completing the drawing of the plan, where every area to be irrigated has been drawn with properly spaced emitters, the number and sizes of valves can be determined. As a basic rule, valves should be split into equal flows.

Complete and insert Table 5 in the project proposal. Add rows as needed.

Table 5 Valve Details

Valve Type (Gate, Ball, Solenoid, backflow preventer, etc.)	Size	Quantity
Insert text here	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*
Insert text here	*Insert text here*	*Insert text here*

Please provide valves datasheet, highlighting selected model and operating conditions, if applicable.

4.2.4 Pump

Pump sizing depends on the required flow, water velocity and pressure losses in the system. Pump operating curves or software can be used for sizing to ensure adequate water delivery and reduce unnecessary energy consumption. Flows and pressures are determined by emitter manufacturers and the irrigation-scheduling plan. The pressure to be delivered by the pump is determined by the pressure needed to properly operate the drippers and sprinklers. Emitter manufacturers set pressure requirements. Added to the pressure needed by the emitters are friction losses in pipes and fittings and pump efficiency. The flow of the pump is determined by the flow of each emitter multiplied by the number of emitters operating at the same time in one section.

Complete and insert Table 6 in the project proposal. Add rows as needed.

Table 6 Pump Details

Type of Pump (Centrifugal, booster, etc.)	Brand	Model	Operating Conditions		Power (in kW)
			Head (in m)	Flow (in m^3/h)	
Insert text here	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*

Please provide pump datasheet, highlighting selected model and operating conditions.

4.2.5 Flow Meters

Flow Meters should be installed at the pump level to monitor water consumption volumes and any potential leaks.

Please provide flow meter datasheet, highlighting selected model and operating conditions.

4.2.6 Filters

Filter sizing depends on the quality of water especially relating to solids content. Filters could be installed on the main supply line and on the laterals in the case of drippers or any other type of micro-irrigation. Main filters should be equipped with gauges before and after the filter to detect clogging and clean the filters. Clogged filters increase pressure on the pump and lead to unnecessary energy consumption.

Please provide filter datasheet, highlighting selected model and operating conditions.

4.2.7 Fertilizer Mixers and Injectors

Fertilizer mixers and injectors deliver fertilizers directly in the irrigation system. They can be manually adjusted or automatic. Automatic mixers and injectors can reduce over fertilization if properly operated. Fertilizers and over-fertilization are a cause of water pollution surface and ground.

Please provide filter mixers and injectors datasheet, highlighting selected model and operating conditions.

4.2.8 Automatic Controller

Controllers automatically operate the irrigation system based on timed application of water. They can be simple timers set by the gardener based on the irrigation scheduling study or they can be coupled with a simple weather station and/or tensiometers to accurately time and dose irrigation based on weather conditions, thus, tremendously reducing unnecessary water use and supplying only the necessary plant water requirements.

Please provide automatic controller datasheet, highlighting selected model and operating conditions.

4.2.9 Moisture Monitors (Tensiometers)

Tensiometers measure actual soil moisture content and can be connected to above controllers to prevent irrigation when enough water is still in the soil from a previous irrigation or from a rain event. Moisture sensors can be wired or wireless and should be installed as per the recommendations of the manufacturer taking into consideration soil and plant variability.

Please provide tensiometer datasheet, highlighting selected model and operating conditions.

4.2.10 System Installation

Installation costs for the efficient irrigation system only are covered under the LEA financing mechanism. Good installation practices must avoid leaks as it is a major source of water loss. Irrigation systems should be watertight and must be pressure tested at installation. Leaks from pipes and emitters should continuously monitored to reduce water loss and prevent plant death from water logging or dryness if the emitter stops receiving water.

5. Environmental Sustainability Analysis

Environmental sustainability analysis is the calculation of the water savings that will arise upon the implementation of the efficient irrigation system for agricultural practices. Project proposals submitted under the LEA financing mechanism should compute water requriements by using CROPWAT, a computer program developed by the Land and Water Development Division of Food and Agriculture Organization of the United Nations (FAO). CROPWAT is a decision support tool that allows to calculate crop water requirements and irrigation requirements based on soil, climate and crop data. It is a free-of-charge computer program for irrigation planning and management.

You can download CROPWAT from the following link:

http://www.fao.org/land-water/databases-and-software/cropwat/en/

Meteorological data can be obtained from CLIMWAT. It is a climatic database to be used in combination with CROPWAT to calculate crop water requirements, irrigation supply and irrigation scheduling for various crops. It provides meteorological data from over 5,000 climate stations worldwide, among which 14 are in Lebanon. See the full list of the 14 list of climate stations in Annex 1.

You can download CLIMWAT \ for CROPWAT from the following link:

http://www.fao.org/land-water/databases-and-software/climwat-for-cropwat/en/

If the project proposal is not located near one of the climate stations, please use rainfall data of the World Bank Climate Change Knowledge Portal from the following link:

http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisCCode=LBN

Run the software and print the results on an A4 (size 114 × 162 mm) and attach it to the technical study.

Important Note: The above calculations are valid for open-air cultivation and not greenhouses. Greenhouses have different shapes and forms. They are managed differently in different countries especially in terms of environment control. Almost all greenhouses are irrigated using drip irrigation reflecting savings in water. The greenhouse structure adds to water saving due to increased humidity and climate control. Recent research has demonstrated an almost doubling of water use efficiency between soil and greenhouse grown crops such the case of tomatoes.

6. Irrigation Scheduling per Hydrozone

Areas of land to be irrigated are divided into plots/sections and irrigated one after the other and not all at the same time. A piece of land can be divided into several sections. Sections are not irrigated altogether but in rotation one after the other. Flows to each section should be almost equal. The time interval between one irrigation to another in the same section is determined by the amount of water stored in the root zone (the length of the root) and the amount of daily evapotranspiration. The root zone is considered as a reservoir that is filled with water and gradually emptied by evapotranspiration to be refilled again by the next scheduled irrigation. The root zone should only be emptied up to 40% of its content and not more, otherwise the plants will wilt. If, for instance, the root zone is 50 cm, water content in 40% of the root zone can be safely depleted before the next scheduled irrigation. As such, 20 cm of water can be depleted before the upcoming irrigation cycle. If, for instance, the specific daily evapotranspiration is 0.8 cm/day than the interval between irrigation cycles is 25 days. Accordingly, this plot of land can be divided into a max of 24 sections that can be irrigated daily and in turn. The flow required by the pump is the flow needed for one section at a time not all the garden. Scheduling irrigation reduces the sizes of mainlines and pumps, thus reducing costs and energy requirements.

Complete and insert Table 7 in the project proposal.

Table 7 Irrigation Schedule

Hydrozone	**Root Zone (in cm)**	**ET_L (in mm/day)**	**Irrigation schedule (in days)**
1	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*

7. Summary Table

Upon the completion of the study, complete and insert Table 8 in the project proposal.

Table 8 Summary Table

Hydrozone	**Area (in m²)**	**Method of Irrigation**	**Evapotranspiration Rate of the Hydrozone (ET_L) (in mm/year)**	**Irrigation Schedule (in Days)**	**Water Savings (in L/year)**
1	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
2	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
3	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*	*Insert text here*
				Total Water Savings in L/year	

N.B: 1 mm/year = 1 Liter/year

III. Soilless Agriculture- Hydroponics.

In addition to using the most efficient irrigation systems to contribute to efficient water use in agriculture, new agriculture techniques have additionally improved water use and corresponding yield. Soilless agriculture, known under different names such as hydroponics, aeroponics, Nutrient Film Technique (NFT), uses a growth medium or water mixed with fertilizers to grow plants.

Soilless culture is growing agricultural crops and flowers without the use of soil. There is no loss of water in soil; it is all taken up by the plant. It is highly efficient in water consumption and has no impact on water bodies from fertilizer and pesticides when a closed loop system is used. As opposed to open loop systems, closed loop soilless agriculture conserves water and nutrients by recycling some of the drainage solution back into the system and not discharging it into a receiving environment. Discharged volumes vary from almost zero to around 15%. The discharged volume called drainage can be reused in irrigating adjacent lands in open soil culture if any.

In parallel to water saving, hydroponic productions systems save on land. Hydroponic production uses much less land for the production of the same amount of produce planted in soil. Hydroponic production can be done in marginal lands and even on concrete surfaces such as rooftops.

Instead of soil, plants are grown either in a nutrient solution or in inert substrates such as coco peat, Rockwool or perlite. Nutrients are delivered to plants through the irrigation system. Soilless culture reduces pollution from agriculture by preventing the discharge of fertilizers and pesticides into soil, surface and groundwater. The main advantage of hydroponics is the high yield of quality A products per area planted and per consumed water volume. Irrigation and nutrients are provided through the irrigation system. Nutrient and water dosing are controlled through a computerized unit with sensors and automatic fertilizer dosing systems.

In soilless culture, plants are sometimes grown in highly controlled environments (temperature, humidity, light and CO_2 concentration) and accordingly water and nutrient consumption can be optimized for the highest possible quality of produce and yields that exceed by far soil based cultivation. Pesticide use is minimal in advanced greenhouse systems that are completely sealed to the outside and prevent the entry of insects.

Water needs in NFT to be around 10 times less per kg of crop produced than the water needs of conventional agriculture for the same crop. In Rockwool closed loop systems, around 50% of the water in soil-based agriculture is saved.

In hydroponic production where heating, cooling and artificial light is used, energy use will be of concern. The high-energy requirement can be offset with renewable energy sources such as biomass heaters, wind and sun energy sources, etc.

1. Applicability under LEA

It is important to pinpoint that not all items under soilless agriculture are financed under the LEA financing mechanism. This section provides a clear list of the financeable items to prepare the technical study for soilless irrigation systems.

Components under soilless irrigation eligible under the LEA financing mechanism are:

1. Closed sealed greenhouse or glasshouse (could be automated);
2. Automatic fertigation (fertilization and irrigation) control unit;
3. Automatic environment control system with weather station for advanced greenhouses;
4. Fertigation network and accessories (dosing systems, valves, gages, emitters, etc.)
5. Drainage solution recycling system. A disinfection system, for the drainage solution, might be required in case of substrate-based culture;
6. Flow meters;
7. Crop growing system: liquid (NFT) or substrate based (Rockwool, perlite, coco peat)
8. Mist system to control humidity, if required;
9. Heaters/coolers, if required;
10. Air circulation fans, if required;

It is important to note that only the cost of the hydroponic system will be financed under the LEA financing mechanism. The cost of the agricultural crops for commercial purposes is not financed.

N.B.: Glossary of terms is available in section 4 below.

2. Requirements under LEA

This section covers the requirements under LEA and the information to include in the technical study. As a minimum, the study should include the following:

a. Description of the current state of the agricultural land. Specify:
   - Planted area (in m²);
   - Water source (municipal, rainwater, treated effluent wastewater, private source), quantity and quality;
   - Current water irrigation system, if any.

b. List of crops to be planted;
c. Planting patterns/programs and drawings;
d. System type (NFT, media, etc.);
e. Type of greenhouse;
f. Hydroponic system components (incl. flow meters) and specifications;
g. Drainage solution recycling system design specifications and layout;
h. Irrigation Scheduling;
i. Environmental sustainability analysis;
j. Datasheet of components seeking financing under LEA;
k. Official BOQ from the supplier/contractor that should include:
l. Supplier/Contractor details;
   - Components' unit cost in USD/unit or LBP/unit;

- Installation cost (in USD or LBP).

3. Environmental Sustainability Analysis

The LEA financing mechanism will only finance hydroponics with recirculated and recycled drainage systems. Accordingly, project proposals are requested to present the complete design, specifications and layout including the drainage recycling system. Project proposals should include calculations of the water savings per year.

In addition, project proposals seeking financing for hydroponics are required to install water flow meters, pre-irrigation and recycled water branch to demonstrate the recycling rate.

4. Glossary of Terms

Normal greenhouses. Normal greenhouses, currently used in soil-based agriculture, can be used in soilless systems with minimum modifications.

Automated sealed greenhouse or glasshouse. For highest yields, hydroponic production needs a strict environment control as relates to temperature, humidity, light and CO_2 levels. Consequently, there arises the need for a controlled environment achieved only through closed greenhouses with automated ventilation, light, CO_2 and temperature control systems linked to a weather station and parameter sensors. Greenhouses are operated through a computerized controller.

Automatic fertigation (fertilization and irrigation) control system. The main advantage of hydroponics is the delivery of plant nutrients in exact amounts straight to the plant. A fertigation unit consists of liquid fertilizer tanks, pumps, sensors, dosing units, pumps and miscellaneous accessories.

Drainage solution recycling system (UV disinfection). Unused irrigation water is recycled, cleaned, re-dosed with fertilizers and injected back into the system. Cleaning is usually through a filtration and UV unit to disinfect the water.

Automatic environment control system with weather station. As mentioned above, fertigation and greenhouse environment is controlled through computerized systems linked to sensors, weather stations and pumps.

Fertigation network and accessories (valves, gages, emitters, etc.) Similar to an irrigation system, a fertigation system is designed using the same parameters as for normal irrigation systems in terms of flow and pressure. Water management is, however, adapted to the needs of the plant with more variability in management as compared to conventional irrigation.

Crop growing system: liquid or substrate based. As mentioned previously, plants are grown either in a film of water and nutrients or in inert media such as coco-peat, Rockwool, or perlite.

Mist system. Systems consisting of pumps, pipes and spray nozzles are used to control humidity in the greenhouses.

Heaters and coolers system. Temperatures control might be required in hydroponics and accordingly air and/or water heating/cooling systems might be required. Fans are also used for humidity control. Plastic covering of greenhouses can come as inflatable double layer which serves as insulation from heat loss.

The fertigation and greenhouse control unit. The unit should enable an accurate control of irrigation and fertilizer mixing and delivery and operate the greenhouse in order to optimize its environmental parameters. Water delivery should be properly dosed and timed as per the plant requirements including scheduling with the potential to adapt irrigation to the growth stage of the crop and season. Drainage water should be as minimum as needed for leaching accumulated salts.

The mist system. Humidity control is essential in hydroponics. Mist systems are used to increase the levels of humidity inside greenhouses in order to promote growth. Different mist systems operate at different pressures. The system with the lowest pressure requirements should be selected in order to reduce energy needs.

IV. Annex

1. Annex 1

Effective Rainfall in mm/year.m² from 14 climate stations in Lebanon.

Elevation Range (m)	Location	Elevation (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
North 1 From ARIDA to BATROUN															
0-250	**Abdeh**	**10**	130.2	103	93.2	50.2	15	1	0	1	8.9	72.7	84	142.3	701
0-250	**Tripoli**	**15**	123.3	98.2	89.3	44.3	15	3	1	1	6.9	59	91.9	122.4	655
0-250	**Qlaiat Airport**	**1**	138.8	99.4	90.6	44.3	18	1	1	1	12.7	24	90.6	117.6	639
>1,100	**Al Arez**	**1,940**	147.6	138.4	111.4	60.6	30	5	1	1	5	30.4	79.2	118.1	728
North 2 From BATROUN to BEIRUT															
0-250	**Beirut**	**40**	134.2	94.5	88.7	44.3	18	1	1	0	8.9	33	113.5	113	649
South 1 From BEIRUT to SAIDA															
0-250	**Bhamdoun**	**800**	155.2	151.2	133.8	80.6	37	1	0	0	3	49.3	104.1	147.6	863
South 2 From SAIDA to NAKOURA															
0-250	**Tyr**	**5**	140.1	90	69.8	39.2	5	0	0	0	5.9	37.4	84	136	607
250-450	**Alma El Chaab**	**383**	130.6	118.1	62.2	30.4	9.8	1	0	0	4	29.5	64.5	129.8	580
650-850	**Marjayoun**	**750**	133.4	128.6	102.4	64.5	25	1	1	1	3	23.1	77.8	120	681
650-850	**Ein Ebel**	**740**	134.2	126	85.4	48.5	5.9	1	0	0	4	30.4	58.2	128.6	622
North Beqaa From BAALBACK to HERMEL area															
> 950	**Chlifa**	**1020**	81.3	69.8	48.5	29.5	14	1	0	0	1	6.9	43.5	65.2	360
Middle Beqaa From SHTOURA to BAALBACK															
850 - 950	**Ksara**	**910**	109.2	91.9	79.9	39.2	9.8	1	0	0	1	32.2	60.6	105.3	530
850 - 950	**Rayak**	**935**	108.6	89.3	79.2	45.2	16	2	0	0	1	29.5	55	93.8	519
850 - 950	**Tell Amara**	**910**	114	88.7	72.7	38.3	17	0	0	0	1	22.2	51.8	105.3	511